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Dilemma Analysis of China Agricultural Non-point Source Pollution Based on Peasants' Household Surveys

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Abstract

The purpose of this study is to analyze the dilemma in the management of agricultural non-point source pollution from a micro angle and put forward to some proposals. Methods employed include questionnaire surveys and peasants' interviews. Research Results reveal that: agricultural non-point source pollution is not induced entirely by the modern agricultural technology. Rather, it results from the lack of adequate public services provided by the government, which lead to a *high-yield, low efficient and high-input* pattern of agriculture instead of a *high-yield, high-efficient and low-input* one. Peasants have been highly relying on fertilizers and chemicals, and unwilling to adopt an eco-friendly agricultural technology due to the absence of economic encouragement. To control the agricultural non-point source pollution, the government should strengthen its support to public agricultural technology, and take long-run economic measures to encourage peasants to implement eco-friendly agricultural technology actively.

Keywords: Dilemma Analysis; agricultural non-point source pollution; micro angle; Household surveys

1. Introduction

Agricultural non-point source (NPS) pollution mainly comes from chemical fertilizer, pesticide and plastic membrane which are widely used in agricultural production, as well as agricultural or rural waste such as crop residue, animal urine and feces, domestic sewage and garbage and so on. It has such

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characteristics as dispersion, invisibility, difficulty in monitoring, randomness and uncertainty. Therefore it has brought increasingly serious harm to water, soil and air in our country. February 6, 2010 the First National Census of Pollution Sources Gazette [1] promulgated by Environment etc. of Three Ministries shows that the agricultural source discharge in whole country impacts water environment more greatly. In 2007, the discharge amount of chemical oxygen demand (COD) reached to 13,240,900 tons, which was 43.7% of total COD discharge amount. Agriculture is also the main source of total nitrogen (TN) and total phosphorus (TP) discharge. The discharge amounts were 2,704,600 tons and 284,700 tons respectively, accounting for 57.2% and 67.4% of total discharge amount (Table 1). In addition to water environment, natural resources, especially soil for the survival of agriculture, have been severely influenced by agricultural non-point source pollution. As a result, it will directly affect agricultural development and human health in China.

Table 1 National gross amount of the main pollutants emission and emission of agricultural source pollutants in The First National Pollution Source General Survey Bulletin

Pollution Source	Number of Pollution Source	COD(10^4t)	TN(10^4t)	TP(10^4t)
Total Discharge Amount of Pollution in China	5925576	3028.96	472.89	42.32
Agricultural Pollution Source	2899638	1324.09	270.46	28.47

The study on mechanism of agricultural non-point source pollution indicates that the reasons can be mainly attributed to the Pursuit of Growth development concept of agriculture, Urban-rural Dual Economic and Social Structure [2], negative externality of agricultural non-point source pollution [3], high governance costs, and the pressure in household survival and development, short-sighted in agricultural operation behaviors [4], indifferent environmental awareness [5] and etc. In agricultural non-point source pollution abatement, China's agricultural non-point source pollution control measures and management engineering research have reached to the same level compared with developed countries, but most are still in the experimental unit stage, so it is difficult to be widely used. Otherwise, in our country, prevention of agricultural non-point source pollution is also hindered by incomplete legislation, lack of economic incentives and etc. in this field [6]. This shows that it is not only technical issues, but also socio-economic and development issues to control and solve agricultural non-point source pollution, which need to be examined from multidisciplinary perspective. Then, from perspective of the farmers who is such a group with interests closely related to agricultural non-point source pollution, what are the status and plight in prevention and control of China's agricultural non-point source pollution? The investigation mainly focuses on the main application of fertilizers and pesticides in farmers' planting process.

2. Material and Method

This study selected six villages of three towns in Beijing Daxing District, and one village of a town in Yi Country, Hebei Province, with 200 farmers totally to conduct field survey. Beijing Daxing District, as a more economically developed region, is an intensive vegetable planting and protected agriculture developed area. It is located in southern suburbs of Beijing. The whole area is 1036 km^2 with a total population of 58.1 million including 31.9 million rural populations, and existing cultivated land area of 576000 mus, with 220000 mus of vegetables, 100000 mu of melons. In the study, three towns selected are developed agricultural town in Daxing District, with 3 to 6 mu of arable land per capita. However, Yixian County in Hebei Province represents non-intensive planting region and protected agriculture of under developed area. The total area of Yixian County is 2534 km^2 including total cultivated land area of 62 mu. The town studied is located in mountainous area, with less than 1 mu of arable land per capita.

Field investigation was mainly based on questionnaire surveys, by means of face to face interviews with farmers. The questionnaire was undertaken on 200 villagers in all, comprised of 30 households in each village in Daxing District, Beijing and 20 households in one village of Yixian Country, Hebei. At the same time, group interviews and case depth interviews were carried out in each village, a wealth of research materials were collected by the research team. The region, sex, age and educational level distribution of surveys are listed in Table 2.

Table 2 The distribution of investigation samples' gender, education level and age in Beijing and Hebei(%)

Category		Beijing	Hebei	Sum
Village		6	1	7
Sample		90	10	200
Gender	Male	42.78	80	46.5
	Female	57.22	20	53.5
Education Level	Above Junior High School	15.56	10	12.22
	Junior High School	66.67	30	60.37
	Primary School	11.67	45	21.48
	Below Primary School	6.11	15	5.93
Age（Year）	>=70	1.11	10	2
	60-70	6.11	30	8.5
	50-60	34.44	45	35.5
	40-50	48.89	10	45
	30-40	9.44	0	8.5
	<30	0	5	0.5

3. Predicament of agriculture NPS prevention in from microcosmic point of view

3.1. Man should not ascribe non-point pollution in agriculture to Modern Agriculture—High Yields, High Quality, High Efficiency, but to meditate why the farmers did not put environment friendly field management techniques into practice meanwhile?

China began revolution in agricultural science and technology in the 1980s. The representative contents were the large-scale promotion of hybrid rice and excellent types of semi-dwarf conventional rice, hybrid corn and semi-dwarf wheat, with techniques of the cultivation and the improvement of the multiple crop indexes. Its precondition is the greatly increasing irrigated area, fertilizer and pesticide use [7]. As a result, cyclical, ecological balance, environmental friendly features of China traditional agriculture are gradually transformed into modern agriculture of high-yield, quality and efficiency, relying on chemical fertilizers and pesticides to ensure continuous growth of production. Substantial increase in grain production in China provides guarantee for food safety. But it also brings a series of issues such as excessive use of fertilizers and pesticides, flood irrigation and so on, coupled with livestock scale farming and the level of total production rising, as a result, environmental problems are more and more clear and getting worse. Taken the food crops of corn as an example, corn commercialization ratio of two research regions is both above 80%. The general process and application rate of chemical fertilizer are as follows, base fertilizer diamine is 15-25 kg / mu, top application urea is 15-35 kg / mu, a season of corn amounts 30-60 kg / mu fertilizer. Statistics in the amount input of chemical fertilizer of 156 corn

farmers indicate that there are 90.48% of them above common international safety limit 225 kg / ha (15 kg / mu) and 78.57% above the average level of national fertilizer statistics estimate 444 kg / ha (about 30 kg / mu) [8] (Table 3). There are no significant differences in the amount of chemical fertilizer between intensive and non-intensive cropping areas. Because of this kind of intensive agriculture based on industrialization, large number of technical, financial and material resources input, food production has been greatly improved but accompanied by increasing problems in agricultural non-point source pollution.

Table 3 The chemical fertilizers input of corn in investigated peasants (%)

Corn yields per mu	Fertilizers input (kg/mu)						
(jin)	0	<=15	15-30	30-60	60-90	90-150	>=150
Total	3.21	7.69	13.46	46.79	16.67	10.26	1.92
400-699	0.00	12.50	0.00	50.00	12.50	25.00	0.00
700-999	3.39	8.47	18.64	40.68	13.56	10.17	5.08
1000-1299	4.55	4.55	12.12	51.52	18.18	9.09	0.00
>=1300	0.00	0.00	33.33	33.33	33.33	0.00	0.00
Beijing	3.55	8.51	13.48	44.68	17.73	10.64	1.42
Hebei	0.00	0.00	13.33	66.67	6.67	6.67	6.67

Therefore, many scholars believe that modern agriculture of high yield, quality, and efficiency is one of important reasons in agricultural non-point source pollution. Because modern agriculture is intensive agriculture based on industrialization, large number of technical, financial and material resources input. This intensification of agricultural production patterns could be more likely to cause environment pollution, so that the process of economic growth is accompanied by increase of agricultural pollution [9]. Wen Tiejun [10] holds similar opinions. However, the author believes that the root cause of agricultural pollution is not only modern agriculture of high yield, quality, efficiency, but also the abuse of chemical fertilizers and pesticides, which caused by the farmers who do not master the right and environment-friendly farm management techniques during chemical fertilizers and pesticides application leading to non-point source pollution. In survey, 86 percent of households considered that they had a good grasp of fertilizer and pesticide application technology themselves. However, the research indicated that the level of farmers' field management was low. The 43 corn high yield experiments in whole nation showed that the lowest yield was 10 tons per hectare and average yield was 15 tons, the highest reached 21 tons per hectare, but the same maize varieties to farmers, the yield was only 6 tons per hectare. Except corn, the yield of other crops like wheat, rice etc., were also low. Similarly, high quality varieties breeded by specialist were planted in farmers' fields, but the average yield was less than half of the experts' [11]. The main reason is that farmers did not master the environment-friendly field management techniques well. At present, sales channels of fertilizers and pesticides, farmers used, are all run through by the market, commercial channels. When farmers meet problems in production process, most of them have to turn to commercial channels. In the research, when the pests appear in the production process, 95 percent of the farmers usually consulted pesticides sellers on the market, but almost nobody is willing to consult the agricultural extension workers of township. Fertilizer application is in the same situation. In fertilization process, 75% of households decide the amount of fertilizer mainly according to past experience, while only 11% would like to consult professionals. At the end of last century, China's primary agricultural extension system basically paralyzed with the implementation of the reform of rural institutions. Agriculture public services, especially technical services were seriously absent. Obviously, the government has failed to provide good public services to agricultural production guidance for farmers.

The survey shows that, although rare opportunities for farmers to consult the agricultural technicians, still 86% of households believed that they needed access to agricultural technical guidance. Especially farmers with facilities for agriculture, 96% of them expressed the need of agricultural technical guidance. Therefore, if the government can provide high quality, adequate agricultural public services to ensure a good team of grass-roots agricultural techniques extension to help farmers master or adopt environment-friendly field management techniques and learn to enhance the utilization of fertilizers and pesticides, so that agricultural non-point source pollution problem can be controlled.

3.2. Under the industrialization background, since high dependence on chemical fertilizers and pesticides has become the mode of production and production habits for peasants, agricultural development and non-point source pollution' prevention and control are restricted.

Fertilizers and pesticides play a vital role to ensure that food production. As the application of fertilizers and pesticides, farmers can be released from heavy labor, therefore they can obtain the higher benefits of food and agricultural products with less time.

In developing countries, in urban development and industrialization-oriented development stage, the farmers engaged in industrial production and urban services can earn more than in agriculture. Urban and modern life is naturally attractive to farmers, particularly to young farmers. Agricultural practitioners are no longer rural elites, mainly the elderly and women instead. In this case, relying on chemical fertilizers and pesticides to ensure production, rather than intensive cultivation for their own land becomes a rational choice. In survey, 93 percent of the farmers consider that fertilizers and pesticides are used every year, otherwise the crops will not grow well. It is obvious that high dependence on chemical fertilizers and pesticides has become the mode of production and production habits for peasants. The survey finds that though the government devotes great efforts to develop agriculture facilities and other modern agricultural techniques, agricultural non-point source pollution is more serious on the contrary. The reason is that it is difficult for the farmers to change the customs in production, and most of them still rely on chemical fertilizers and pesticides. In 2010 the total area of facility agriculture in Daxing district has reached to 100000 mus, making up nearly 50% of the total area facility agriculture in Beijing [12]. Agricultural facilities because of its high-tech, can not only reduce pollution, provide high-quality and fresh agricultural products, but also reduce the incidence of pests and diseases and cut down the amount of pesticides use by the ambient temperature and humidity control [13]. Facility agriculture is resource-saving and environment-friendly agriculture, which can also significantly increase farmers' incomes. However, it is found that agricultural facilities of research regions have further increased the agricultural non-point source pollution. Of 200 households investigated, 96 households possess facilities agriculture (greenhouses and cold canopies). There are a total of 65 mus of greenhouses and 40 mus of cold canopies. They are all located in Daxing district of Beijing. These agriculture facilities are established through the way of support of government and fund from farmers.

- Pesticide

56 % of facility agriculture households thought that there were much more pesticides used in greenhouse than bare land (openground), and 88% of these peasant households filled in the reason for " the planting technology was difficult to master due to the high humidity and temperature in greenhouse, causing more insect pests". Villager B (male, 38 years of age, having two mus for planting watermelons in greenhouse) pointed out his family had been planting watermelons for generations, the watermelons in bare land were never damaged by insects such as mites and trialeurodes, but the watermelons in greenhouse were often subjected to these two pests. By analyzing 43 cases of greenhouse tomato growers, it was also found that the higher the tomato yield was, the greater the amount of pesticide (Table 4) and the dependence of planting tomatoes on pesticide became worse. Villager C (male, 50 years of age,

having one mu for planting tomatoes in greenhouse) said that the tomatoes in bare land had never suffered to insect pests at an earlier time, but the current ratio of being ill for planting tomatoes in greenhouse is higher, and we sprayed pesticides for fifteen times in the whole process from planting to harvest, even twenty times when they were unwell, it meaned that we added pesticides for one or two times a week. Tomatoes must be accompanying by pesticides, and they would have no harvests if no pesticides.

Table 4 The yield and pesticide expenditure of tomato per mu in greenhouse (%)

Pesticide Expenditure	The yield of tomato per mu (jin)					
(yuan)	⩾10000	8000-10000	6000-8000	4000-6000	4000⩽	Total
100⩽	9.09	0	0	25	0	7.14
100-300	9.09	0	44.44	25	40	23.81
300-500	0	60	22.22	33.33	40	28.57
500-700	72.73	40	33.33	8.33	20	35.71
⩾700	9.09	0	0	8.33	0	4.76

- Fertilizer

Fertilizing amount and yield of tomato were positively correlated either. In order to obtain higher yield, farmers must ensure the higher amounts of compound fertilizer, organic fertilizer and defense fertilizer (Table 5). In 43 greenhouse tomato growers, the most rate of fertilizer applications were 150jin urea, 10fang poultry dung and 1080jin dense fertilizer. Those households applying more than 100jin urea or compound fertilizer, over 5fang organic fertilizer and more than 500jin dense fertilizer accounted for 65 percent of the all investigated households.

Table 5 The yield, fertilizer types and amount of tomato in greenhouse

Category		The yield per mu (jin)					
		>=10000	8000-10000	6000-8000	4000-6000	<4000	total
Application rates of urea or compound fertilizer（jin）	<50	0	0	0	25	0	18.6
	50-150	9.09	0	44.44	25	40	30.23
	150-250	9.09	60	22.22	33.33	40	30.23
	250-350	72.73	40	33.33	8.33	20	13.95
	>=350	9.09	0	0	8.33	0	6.98
Application rates of organic fertilizer such as poultry dung or cow dropping（fang）	1-3	0	0	22.22	0	50	11.63
	3-5	0	20	33.33	58.33	16.67	27.91
	5-7	36.36	40	22.22	41.67	16.67	32.56
	7-9	27.27	0	11.11	0	0	9.3
	>=9	36.36	40	11.11	0	16.67	18.6
Application rates of special defense fertilizer of tomato（jin）	0	0	0	44.44	66.67	50	34.88
	<100	9.09	0	11.11	16.67	0	9.3
	100-400	0	20	22.22	16.67	0	11.63
	400-700	18.18	20	22.22	0	50	18.6
	700-1000	63.64	20	0	0	0	18.6
	>=1000	9.09	40	0	0	0	6.98

- Agricultural films

The developments of facility agriculture and vegetable industry had greatly expanded the number and scope of agricultural films, and the films belonged to the disposable products. The facility agriculture development was quicker and the area was bigger, the pollution of agricultural films would be greater. According to the survey, 30% of the 142 households using films would not recycled these films and sold them to vendors, but pouring them into the rubbish (12%), throwing away randomly (10%), burning them on directly (8%).

For facility agriculture production in Israel, almost all of fertilizer was applied through irrigation, the use of fertilizer were not blind and no waste because the production had the quite reasonable parameter to certain trace elements besides having the correct quantitative parameters to N、P、K. The facility agriculture had already achieved the practical application of "plant factory" in China's neighbor Japan, it could produce without the restrictions of natural conditions, and produce such top-quality and pollution-free vegetable products as industrial production everyday [14]. But our survey showed China's installation agriculture was only "facilities reality", no "real technology". It also could be seen from the survey that only 5% of facility agriculture households used the thermometer, hygrometer and other equipments, let in fresh air, control temperature and dried regularly, thus had played the fundamental role of facility agriculture that controlled the insect pest and increased production. Other farmers tended to rely on chemical fertilizers and pesticides during planting in greenhouse, which led to the abuse of chemical fertilizers and pesticides, besides not fully played their roles, aggravating agricultural non-point source pollution. The agricultural production habit of "high dependence on chemical fertilizers and pesticides" enabled farmers to give up the careful and intensive cultivation, and formed the path dependence to the agricultural understanding. It was an difficult event to study the new agricultural technology, change original production habits, reduce the agricultural non-point source pollution and promote agricultural inherent quality due to the seriously absence of ministerial agricultural public service.

3.3. The government had not taken long-term, positive economic driving measures at present, and the farmers had no high enthusiasm to use environment-friendly agricultural technology

At present the awareness of preventing non-point resource pollution was still weak, few people realized that agricultural activities had harmful effects on the environment. 75.3% of the investigated 200 rural households thought the agricultural activities were harmless to the environment. More people realized the bad effect of agricultural activities on environment when narrowing it down to pesticide, fertilizer and agricultural waste, and 42.9% of investigated rural households considered fertilizer was harmful to environment, 61.3% of households thought pesticide had bad effect on environment and 53.1% of households believed agricultural waste were harmful. Even all the farmers aware of the seriousness of agricultural non-point source pollution, the pollution could not be controlled. The farmers needed to depend on land because of facing with the survival and the development pressure, and rural environment belonged to quasi-public goods with competitive and non-exclusive features, which caused the farmers continued to obtain land resource rapidly and consumed excessively, resulting in a "the tragedy of the commons". Like other environmental issues, agricultural non-point source pollution had the strongly negative externalities, thus the process of internalizing external costs couldn't be completed if relying on the market mechanisms purely. This would require the support of the public behavior. In order to solve the problems of agricultural non-point pollution, China developed the study on the control technology and project of agricultural non-point pollution as follows:1.Owing to the project management methods adopted by the end-treatment measures under point source pollution control, such as artificial wetland, vegetation filtration belt and so on; 2. From the ecological point of view, adopting no-tillage—minimum tillage method, soil and water conservation technologies, reducing the use of fertilizer and pesticide, the

control of ground water, integrated control of insect pests and so on; 3. The implementation of integrated control technology including terminal treatment, less tillage farming, farmland cultivation and breeding management. It could also be said that these engineering technologies had already been impartial with the technologies in developed countries. However, they were difficulty to be widely-spread applied due to various reasons. As the main body of agricultural surface source pollution, the production behaviors of farmers would determine directly whether the control of agricultural non-point source pollution was successful. So how to encourage the agricultural households to adopt the environment friendly agricultural technologies to reduce application amount of fertilizer and pesticide? There were two economic measures of government controlling agricultural non-point source pollution: One was the incentive measure, namely integrating the control of agricultural non-point source pollution into the government "green expenditure". Another was punitive measure, insisting on the principle of "who pollutes, who governs" and controlling the emission of agricultural surface source pollution through tax, sewage charges and other economic levers [15]. Looking from the current actual situation of China, it was impossible to limit the use of fertilizer and pesticide or collect punitive taxes from farmers, and the effects of these measures were not very good. While it was a better choice to encourage environmental behaviors of farmers through taking reward-based economic incentive measures and using the positive incentive mechanism. However, our country had not released this kind of economic incentive measures at present, the massive environment-friendly technologies were still promoted in the manner of administration and project. For instance, the Ministry of Agriculture popularized the technology of formula fertilization by soil testing to the whole nation in 2005, farmers used the formula fertilizer or applied fertilizer according to the land area. In addition, Beijing implemented The Construction and Comprehensive Development Plan of Modern Agricultural Infrastructure of Beijing (2009-2012) to promote fostering fertility in farmland, rural cleaning cycle and other engineering constructions. In the 200 surveyed agricultural households, 180 households are villagers of Daxing district of Beijing, and they are being in the promoted area applying formula fertilization by soil testing. But actually only 49% of the agricultural households had heard of "formula fertilization by soil testing", of which 39% households had gotten "the clear card of formula fertilization by soil testing", and 56% households thought "the clear card was useful". On the other hand, Beijing Municipal government subsidied the environment-friendly formula fertilizer, biological pesticides and organic fertilizer to farmers through agricultural departments, the villages and towns organization and the cooperative society, and farmers were glad to accept due to its cheap price and good effects. But at the same time, these fertilizer and pesticides were difficult to meet the daily agricultural production needs because of limited number and low coverage. Obviously, government should take long-term and the positive economic incentive measures to encourage rural households to use the environment-friendly agricultural technologies, which may resolve the agricultural non-point source pollution problems in the long run.

4. Discussion and Suggestions

The occurrence of agricultural non-point source pollution was a comprehensive and complex process, the main implemented body of pollution was the millions of farmers, which determined the difficulty of governance process. The final purpose of agricultural non-point source pollution was to guide the farmers in microcosmic level adjusting their own production behaviors unintentionally, and to take the environment-friendly agricultural production technology. The agricultural non-point source pollution had been attributed to the so-called high yield of "modern agriculture" due to the massive application of fertilizer and pesticide. But on the base of the microscopic investigation, the author thought the development of "high yield, high efficiency" agricultural technology was not wrong, the question lied in the supply of government's agricultural collective services in the application process, leading to "high

production, high efficiency, low input" into "high production, low efficiency, high investment". At present the extension system of China's basic agricultural technology service was paralyzed basically by losses of staff. The technical supplies of fertilizer and pesticide in the commercial system only aggravated the application rates without considering environmental costs. Under the industrialization background, the rational farmers gradually fostered the production way and habit of "highly dependent on fertilizer and pesticide, leaving intensive cultivation". The above reasons had increased the difficulty for agricultural households applying environment-friendly production technology consciously. While guaranteeing the agricultural output and food security in the process of agricultural modernization, households should pay attention to protect the environment. This required that the government realized the present control difficulty of agricultural non-point source pollution, and increased the technological support for government public technology. On the one hand, popularizing and applying the matured technological measures to control the agricultural surface source pollution. On the other hand, government should improve the economic and policy measures, and encourage agricultural households to adopt environment-friendly farming technology. The concrete measures included the following: 1. In the aspect of macroscopic policy, the government should strive to change the urban-rural dual structure, plan the coordinated development of urban and rural areas, and increase investment in agricultural environmental protection; 2. Improve the legislation, and enact the feasible system laws; 3. Change the subsidy way for agricultural households, adopt green agricultural subsidies and other economic incentive measures to strengthen the technological support and advocacy; 4. Pay special attention to the management system from bottom to top, change the current top-down administrative management model based mainly on various of administrative rules and decrees, pay attention to the role of agricultural households and cooperative organizations, and widely carry out every kind of instructive education; 5. Help and advise farmers to master the environment-friendly agricultural technology by reconstructing agricultural technology service organizations, such as the basic agricultural technology promotion.

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